FIG. 1

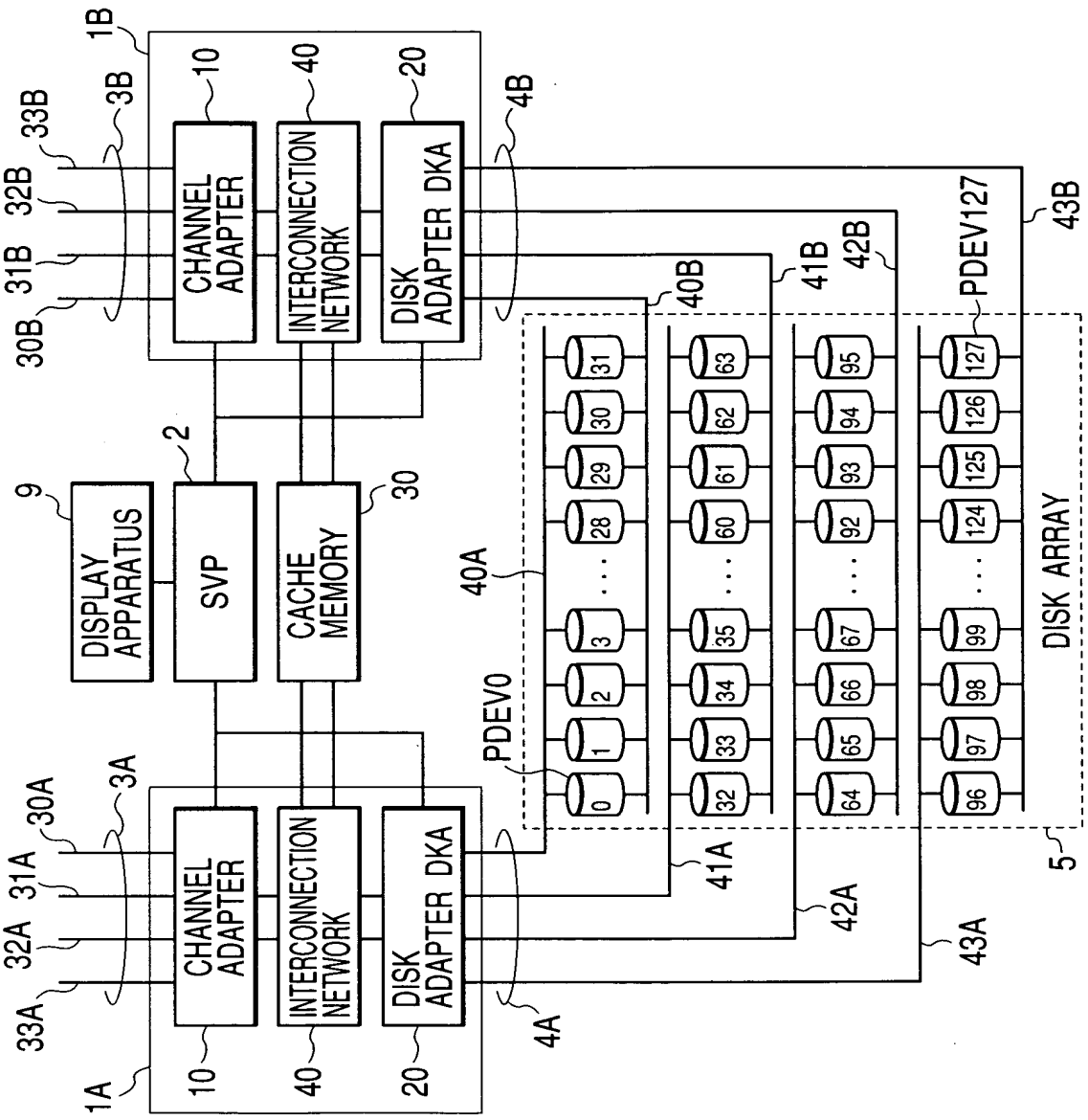

1B
3B
33B
32B
31B
30B
10
40
20
4B
CHANNEL ADAPTER
INTERCONNECTION NETWORK
DISK ADAPTER DKA
2
9
DISPLAY APPARATUS
SVP
CACHE MEMORY
30
40A
40B
41B
42B
PDEV127
43B
PDEV0
41A
42A
43A
5
DISK ARRAY
1A
3A
30A
31A
32A
33A
4A

FIG. 2

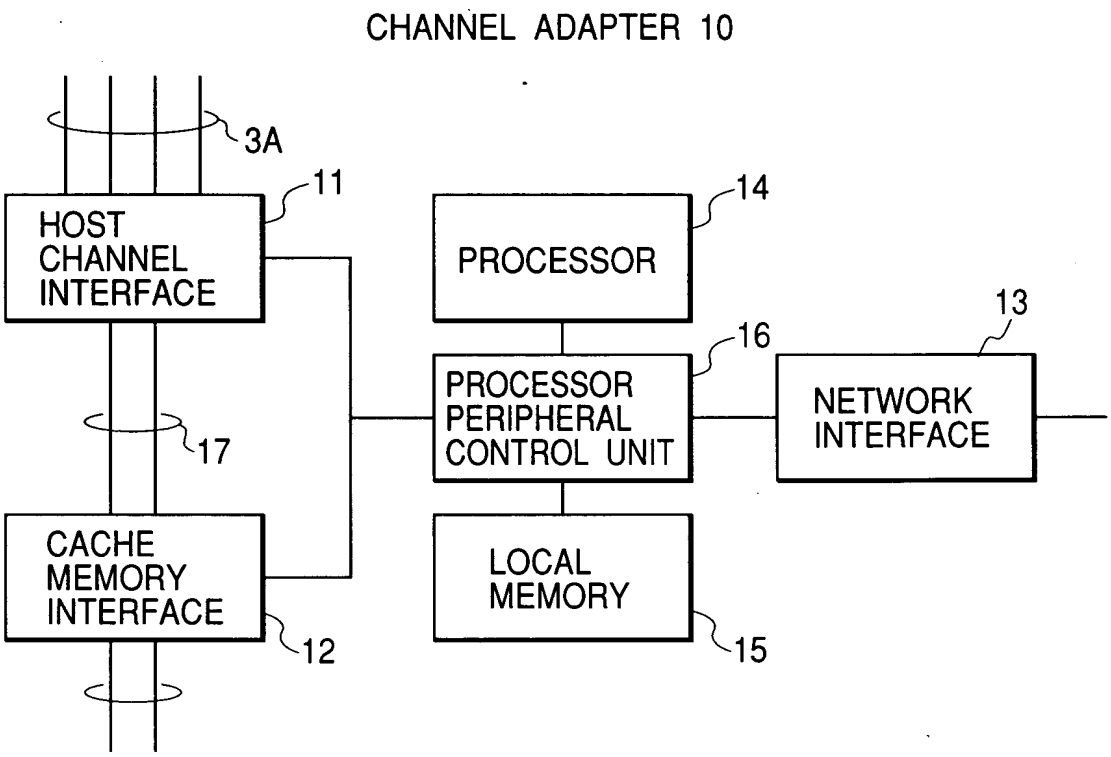

CHANNEL ADAPTER 10
3A
11
HOST CHANNEL INTERFACE
14
PROCESSOR
13
16
PROCESSOR PERIPHERAL CONTROL UNIT
NETWORK INTERFACE
17
CACHE MEMORY INTERFACE
12
LOCAL MEMORY
15

FIG. 3

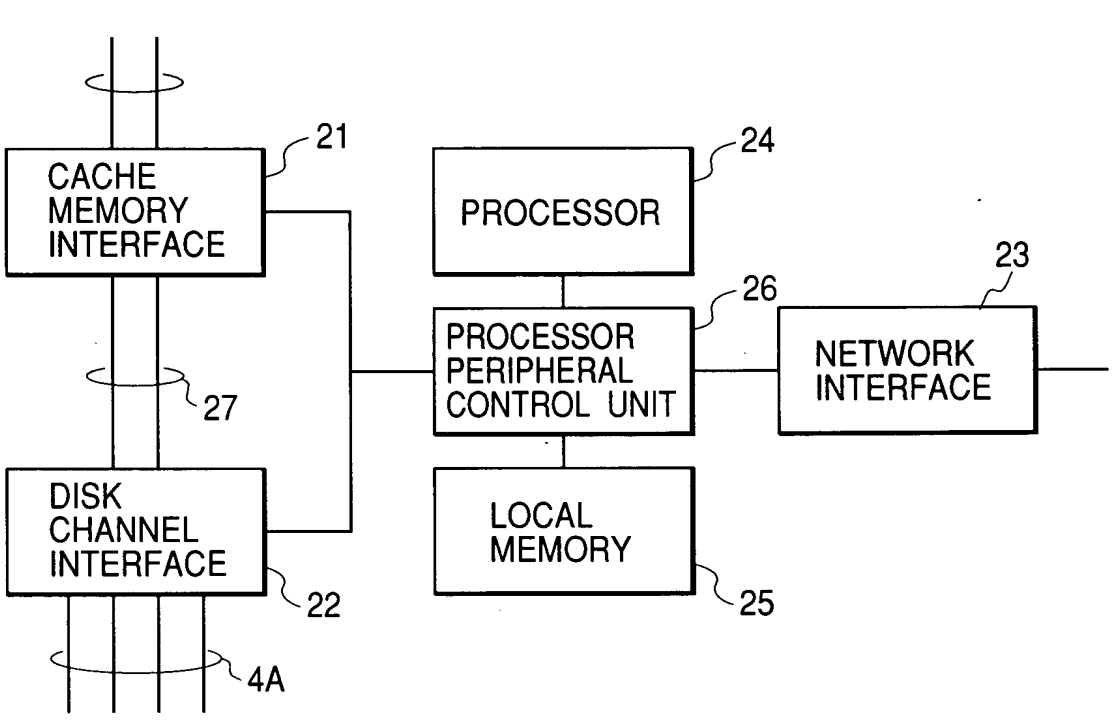

DISK ADAPTER 20
CACHE MEMORY INTERFACE
21
PROCESSOR
24
23
26
PROCESSOR PERIPHERAL CONTROL UNIT
NETWORK INTERFACE
27
DISK CHANNEL INTERFACE
22
LOCAL MEMORY
25
4A

FIG. 4

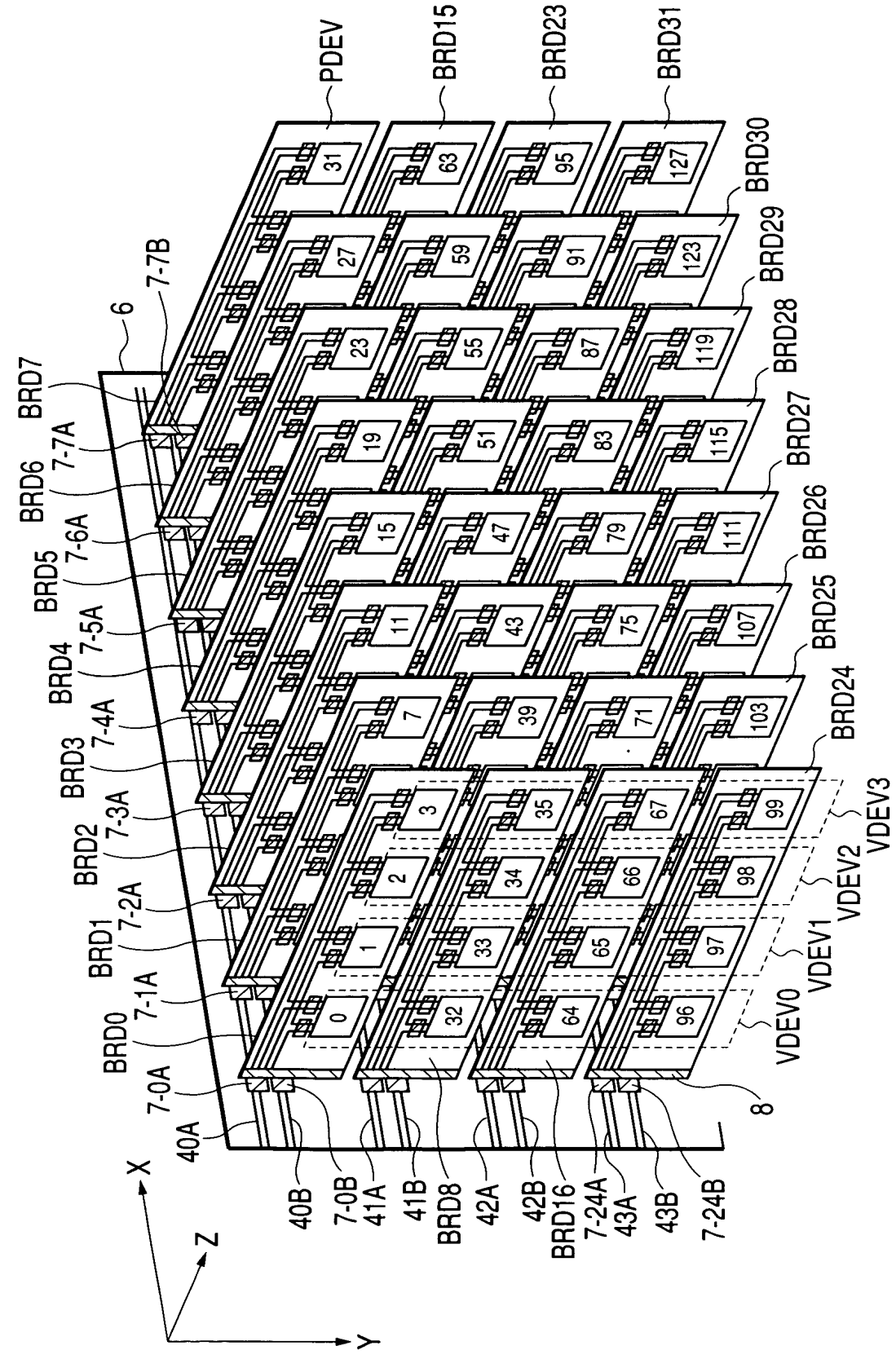

DISK ARRAY 5
PDEV
BRD15
BRD23
BRD31
BRD30
BRD29
BRD28
BRD27
BRD26
BRD25
BRD24
BRD7
BRD6
BRD5
BRD4
BRD3
BRD2
BRD1
BRD0
BRD8
BRD16
6
7-7B
7-7A
7-6A
7-5A
7-4A
7-3A
7-2A
7-1A
7-0A
40A
40B
7-0B
41A
41B
42A
42B
7-24A
43A
43B
7-24B
8
VDEV0
VDEV1
VDEV2
VDEV3
X
Y
Z

FIG. 5

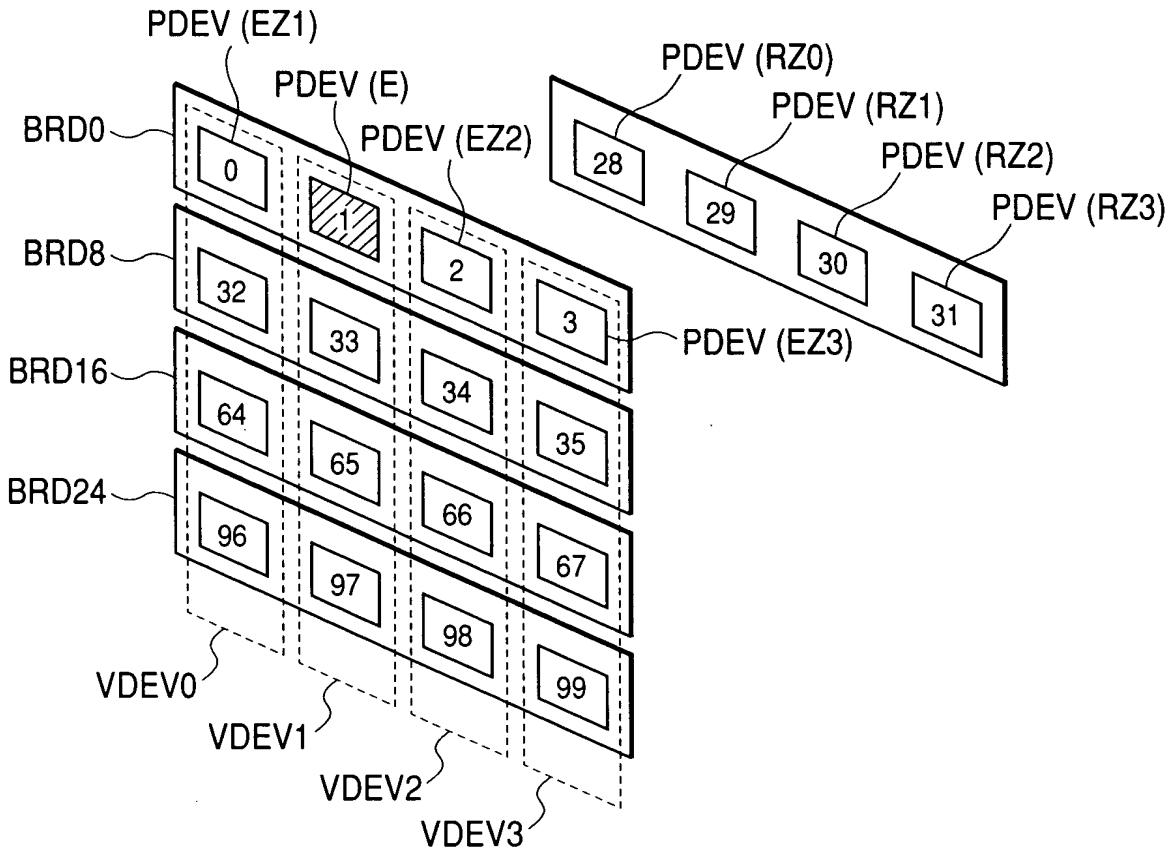

PDEV (EZ1)
PDEV (E)
PDEV (EZ2)
PDEV (RZ0)
PDEV (RZ1)
PDEV (RZ2)
PDEV (RZ3)
PDEV (EZ3)
BRD0
BRD8
BRD16
BRD24
0
1
2
3
28
29
30
31
32
33
34
35
64
65
66
67
96
97
98
99
VDEV0
VDEV1
VDEV2
VDEV3

FIG. 6

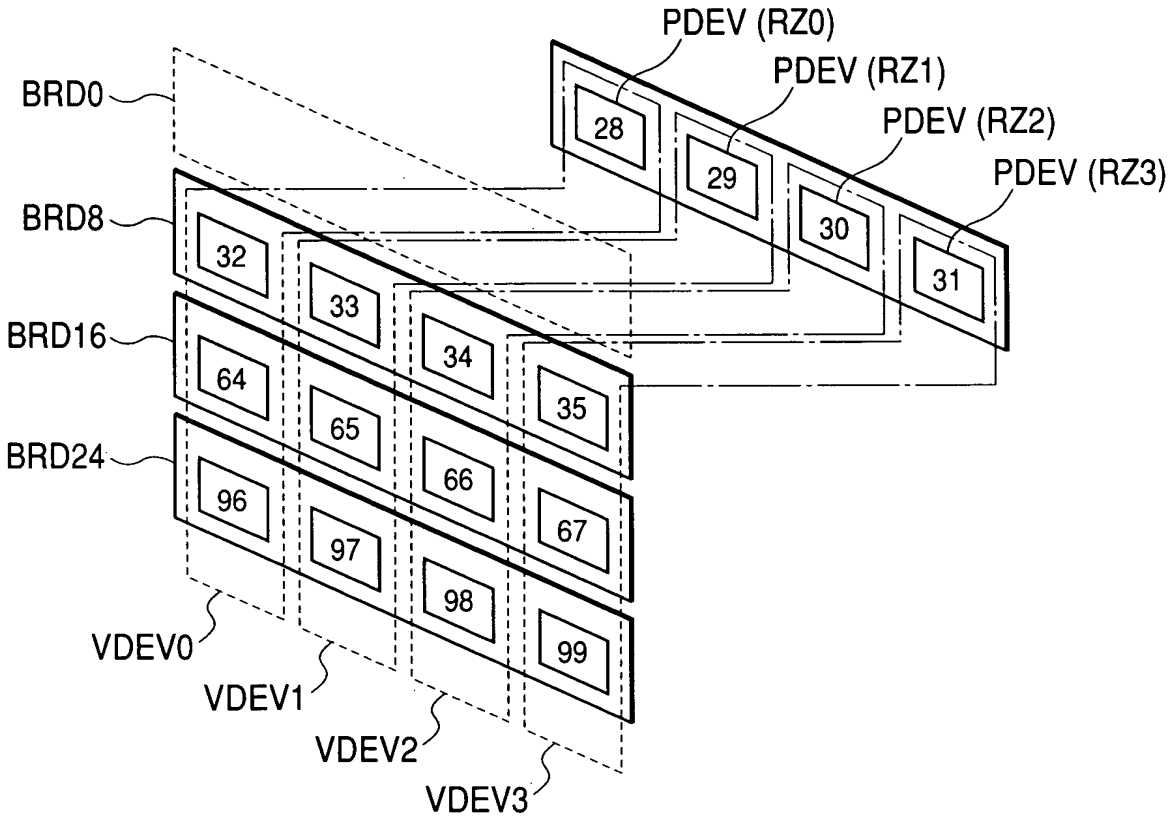

PDEV (RZ0)
PDEV (RZ1)
PDEV (RZ2)
PDEV (RZ3)
BRD0
BRD8
BRD16
BRD24
28
29
30
31
32
33
34
35
64
65
66
67
96
97
98
99
VDEV0
VDEV1
VDEV2
VDEV3

FIG. 7

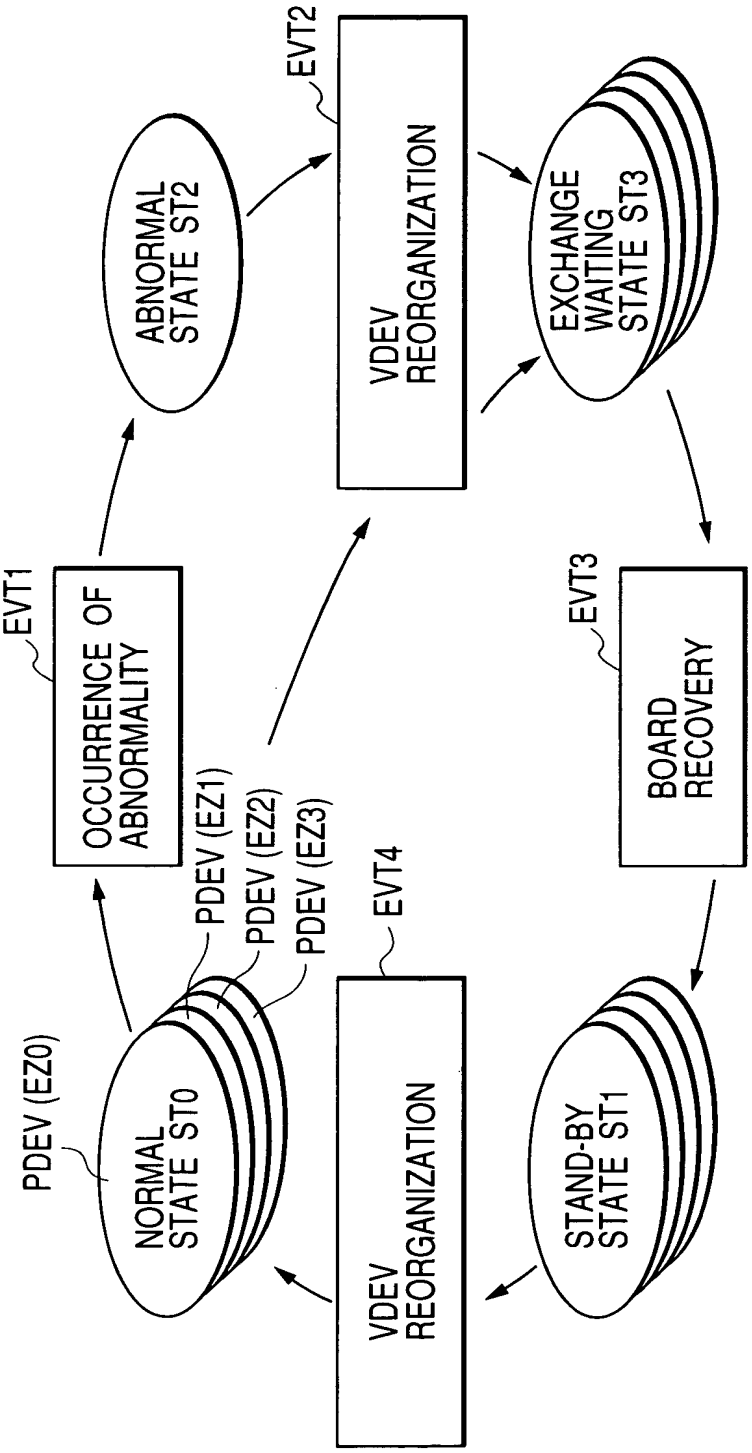

EVT2
ABNORMAL STATE ST2
VDEV REORGANIZATION
EXCHANGE WAITING STATE ST3
EVT1
OCCURRENCE OF ABNORMALITY
EVT3
BOARD RECOVERY
PDEV (EZ1)
PDEV (EZ2)
PDEV (EZ3)
EVT4
PDEV (EZ0)
NORMAL STATE ST0
VDEV REORGANIZATION
STAND-BY STATE ST1

FIG. 8

PORT BYPASS CIRCUIT (PBC) 7

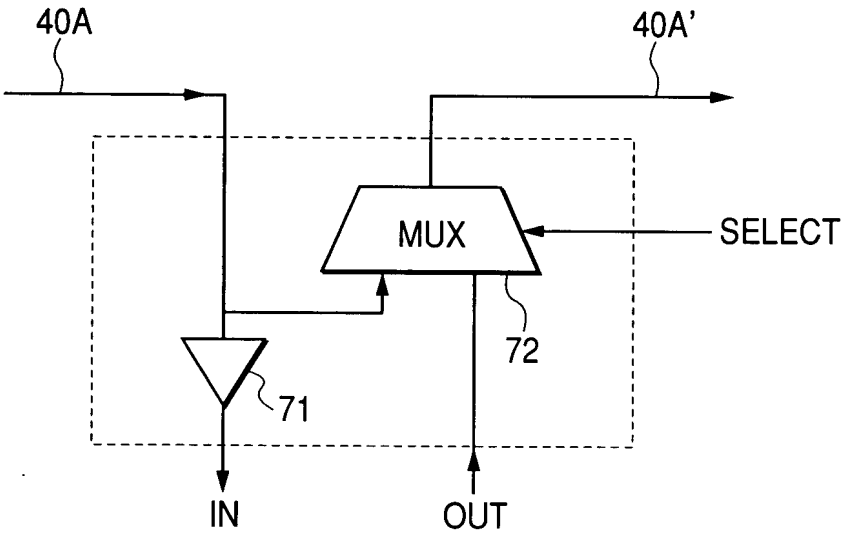


FIG. 9

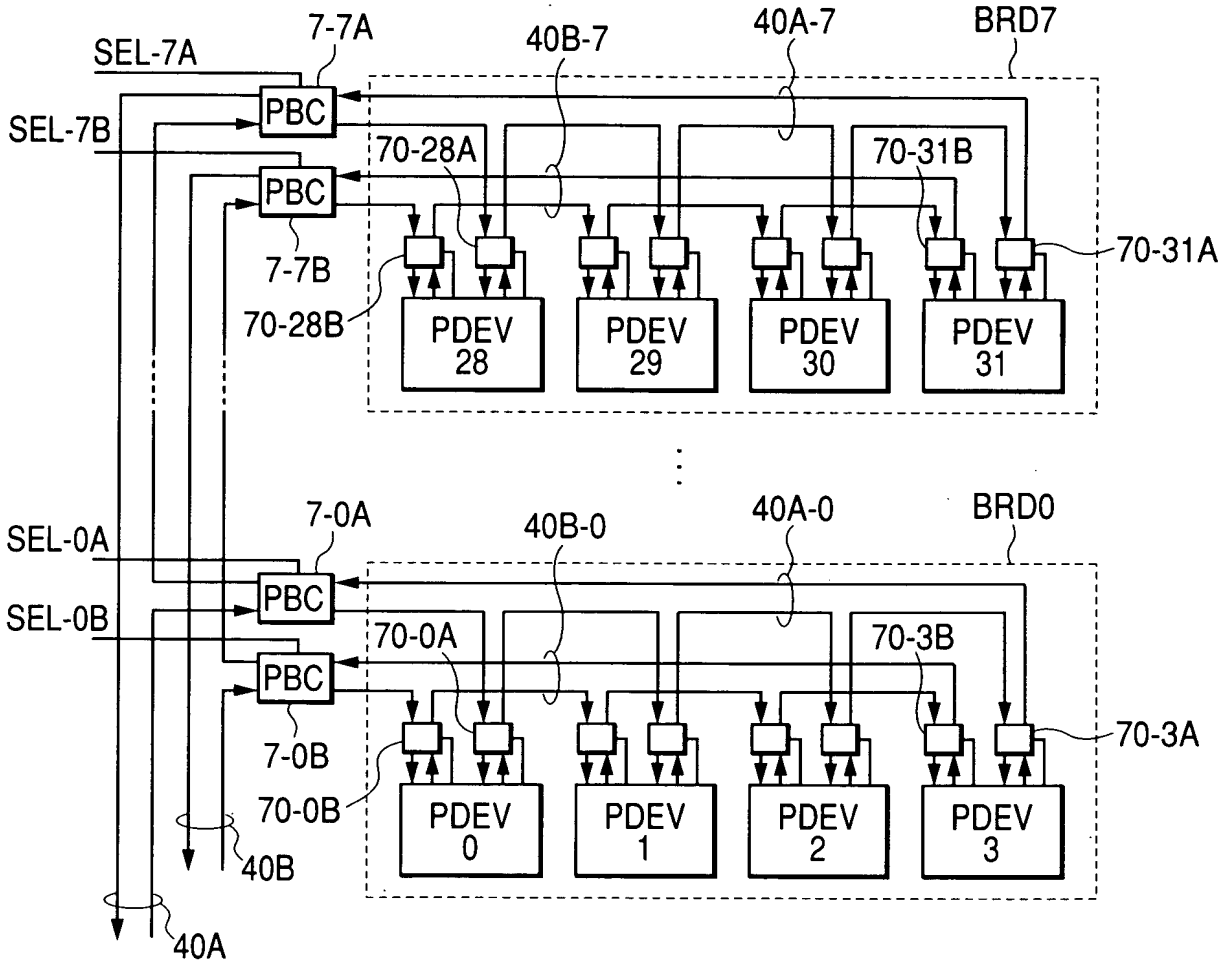

SEL-7A
SEL-7B
7-7A
PBC
PBC
7-7B
70-28B
40B-7
40A-7
BRD7
70-28A
70-31B
70-31A
PDEV 28
PDEV 29
PDEV 30
PDEV 31
SEL-0A
SEL-0B
7-0A
PBC
PBC
7-0B
70-0B
40B-0
40A-0
BRD0
70-0A
70-3B
70-3A
PDEV 0
PDEV 1
PDEV 2
PDEV 3
40B
40A

FIG. 10

BOARD MANAGEMENT TABLE 80

801 BOARD NUMBER: BRD	802 X COORDINATE	803 Y COORDINATE	804 BOARD STATUS CODE	805 DRIVE NUMBER: PDEV	
0	0	0	0	{0, 1, 2, 3}	800-0
1	1	0	0	{4, 5, 6, 7}	800-1
2	2	0	0	{8, 9, 10, 11}	800-2
3	3	0	0	{12, 13, 14, 15}	
4	4	0	0	{16, 17, 18, 19}	
5	5	0	0	{20, 21, 22, 23}	
6	6	0	1	{24, 25, 26, 27}	
7	7	0	1	{28, 29, 30, 31}	
8	0	1	0	{32, 33, 34, 35}	
9	1	1	0	{36, 37, 38, 39}	
10	2	1	0	{40, 41, 42, 43}	
11	3	1	0	{44, 45, 46, 47}	
12	4	1	0	{48, 49, 50, 51}	
13	5	1	0	{52, 53, 54, 55}	
14	6	1	1	{56, 57, 58, 59}	
15	7	1	1	{60, 61, 62, 63}	
16	0	2	0	{64, 65, 66, 67}	
17	1	2	0	{68, 69, 70, 71}	
18	2	2	0	{72, 73, 74, 75}	
19	3	2	0	{76, 77, 78, 79}	
20	4	2	0	{80, 81, 82, 83}	
21	5	2	0	{84, 85, 86, 87}	
22	6	2	1	{88, 89, 90, 91}	
23	7	2	1	{92, 93, 94, 95}	
24	0	3	0	{96, 97, 98, 99}	
25	1	3	0	{100, 101, 102, 103}	
26	2	3	0	{104, 105, 106, 107}	
27	3	3	0	{108, 109, 110, 111}	
28	4	3	0	{112, 113, 114, 115}	
29	5	3	0	{116, 117, 118, 119}	
30	6	3	1	{120, 121, 122, 123}	
31	7	3	1	{124, 125, 126, 127}	800-31

FIG. 11

DRIVE MANAGEMENT TABLE 81

811 DRIVE IDENTIFICATION NUMBER (PDEV)	812 BOARD NUMBER	813 Z COORDINATE	814 MAXIMUM LOGICAL BLOCK ADDRESS	815 PDEV STATUS CODE	
0	0	0	0x1FFFFFFF	0	810-0
1	0	1	0x1FFFFFFF	0	810-1
2	0	2	0x1FFFFFFF	0	
3	0	3	0x1FFFFFFF	0	
4	1	0	0x1FFFFFFF	0	
5	1	1	0x1FFFFFFF	0	
6	1	2	0x1FFFFFFF	0	
7	1	3	0x1FFFFFFF	0	
8	2	0	0x1FFFFFFF	0	
9	2	1	0x1FFFFFFF	0	
10	2	2	0x1FFFFFFF	0	
11	2	3	0x1FFFFFFF	0	
12	3	0	0x1FFFFFFF	0	
13	3	1	0x1FFFFFFF	0	
14	3	2	0x1FFFFFFF	0	
15	3	3	0x1FFFFFFF	0	
16	4	0	0x1FFFFFFF	0	
⋮	⋮	⋮	⋮	⋮	
32	8	0	0x1FFFFFFF	0	
33	8	1	0x1FFFFFFF	0	
34	8	2	0x1FFFFFFF	0	
35	8	3	0x1FFFFFFF	0	
36	9	0	0x1FFFFFFF	0	
⋮	⋮	⋮	⋮	⋮	
122	30	2	0x1FFFFFFF	1	
123	30	3	0x1FFFFFFF	1	
124	31	0	0x1FFFFFFF	1	
125	31	1	0x1FFFFFFF	1	
126	31	2	0x1FFFFFFF	1	
127	31	3	0x1FFFFFFF	1	810-127

FIG. 12

RAID GROUP MANAGEMENT TABLE 82

821 GROUP IDENTIFIER (VDEV)	822 MASTER DISK ADAPTER NUMBER	823 RAID LEVEL	824 COMPONENT PDEV	825 NEW COMPONENT PDEV	
0	0	5	{0, 32, 64, 96}	{28, 32, 64, 96}	820-1
1	0	5	{1, 33, 65, 97}	{29, 33, 65, 97}	820-2
2	0	5	{2, 34, 66, 98}	{30, 34, 66, 98}	
3	0	5	{3, 35, 67, 99}	{31, 35, 67, 99}	
4	1	5	{4, 36, 68, 100}		
5	1	5	{5, 37, 69, 101}		
6	1	5	{6, 38, 70, 102}		
7	1	5	{7, 39, 71, 103}		
8	0	5	{8, 40, 72, 104}		
⋮	⋮	⋮	⋮		
14	0	1	{14, 46}		
15	0	1	{15, 47}		
⋮	⋮	⋮	⋮		

FIG. 13

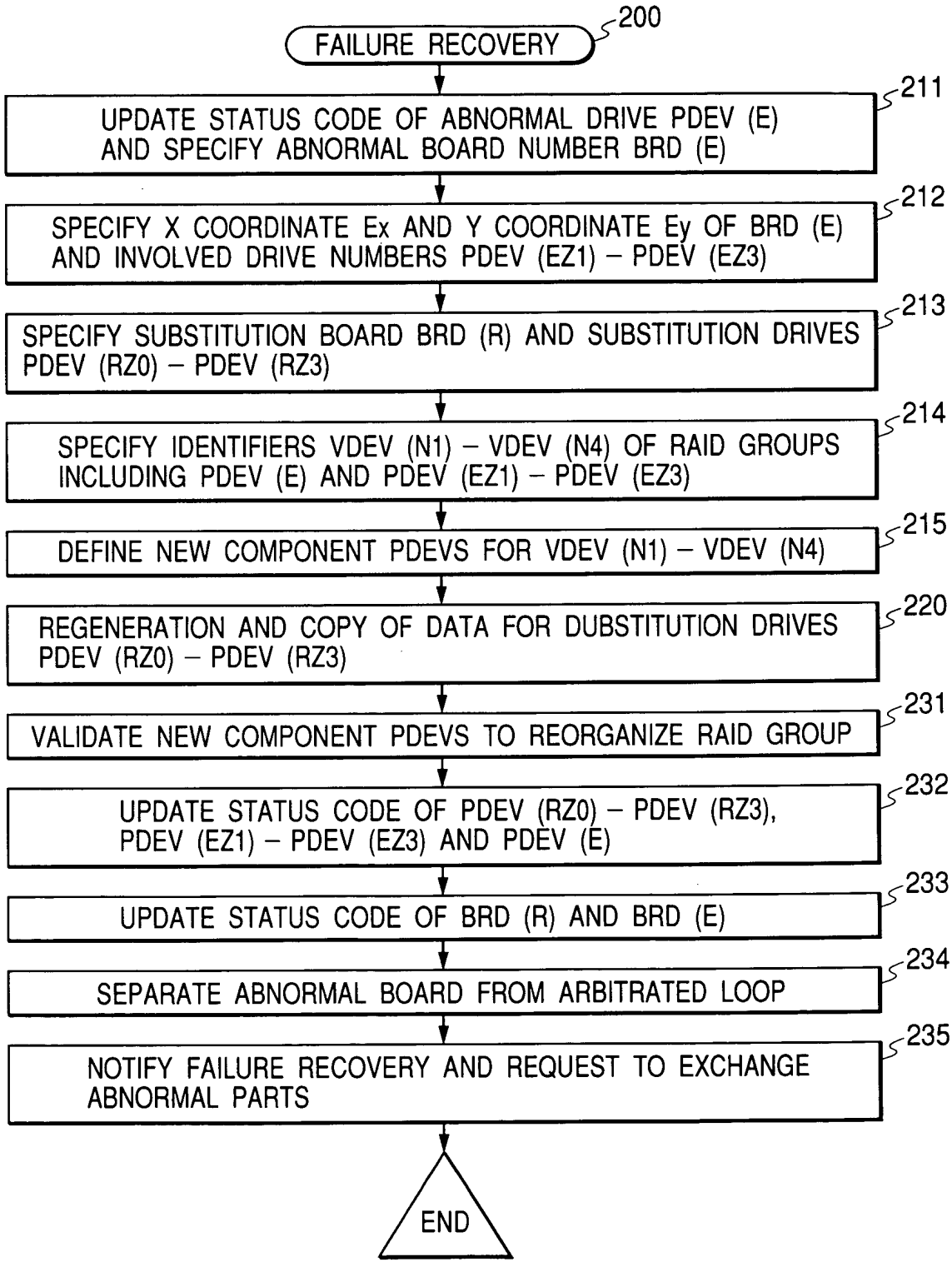

FAILURE RECOVERY
200
UPDATE STATUS CODE OF ABNORMAL DRIVE PDEV (E) AND SPECIFY ABNORMAL BOARD NUMBER BRD (E)
211
SPECIFY X COORDINATE Ex AND Y COORDINATE Ey OF BRD (E) AND INVOLVED DRIVE NUMBERS PDEV (EZ1) – PDEV (EZ3)
212
SPECIFY SUBSTITUTION BOARD BRD (R) AND SUBSTITUTION DRIVES PDEV (RZ0) – PDEV (RZ3)
213
SPECIFY IDENTIFIERS VDEV (N1) – VDEV (N4) OF RAID GROUPS INCLUDING PDEV (E) AND PDEV (EZ1) – PDEV (EZ3)
214
DEFINE NEW COMPONENT PDEVS FOR VDEV (N1) – VDEV (N4)
215
REGENERATION AND COPY OF DATA FOR DUBSTITUTION DRIVES PDEV (RZ0) – PDEV (RZ3)
220
VALIDATE NEW COMPONENT PDEVS TO REORGANIZE RAID GROUP
231
UPDATE STATUS CODE OF PDEV (RZ0) – PDEV (RZ3), PDEV (EZ1) – PDEV (EZ3) AND PDEV (E)
232
UPDATE STATUS CODE OF BRD (R) AND BRD (E)
233
SEPARATE ABNORMAL BOARD FROM ARBITRATED LOOP
234
NOTIFY FAILURE RECOVERY AND REQUEST TO EXCHANGE ABNORMAL PARTS
235
END

FIG. 14

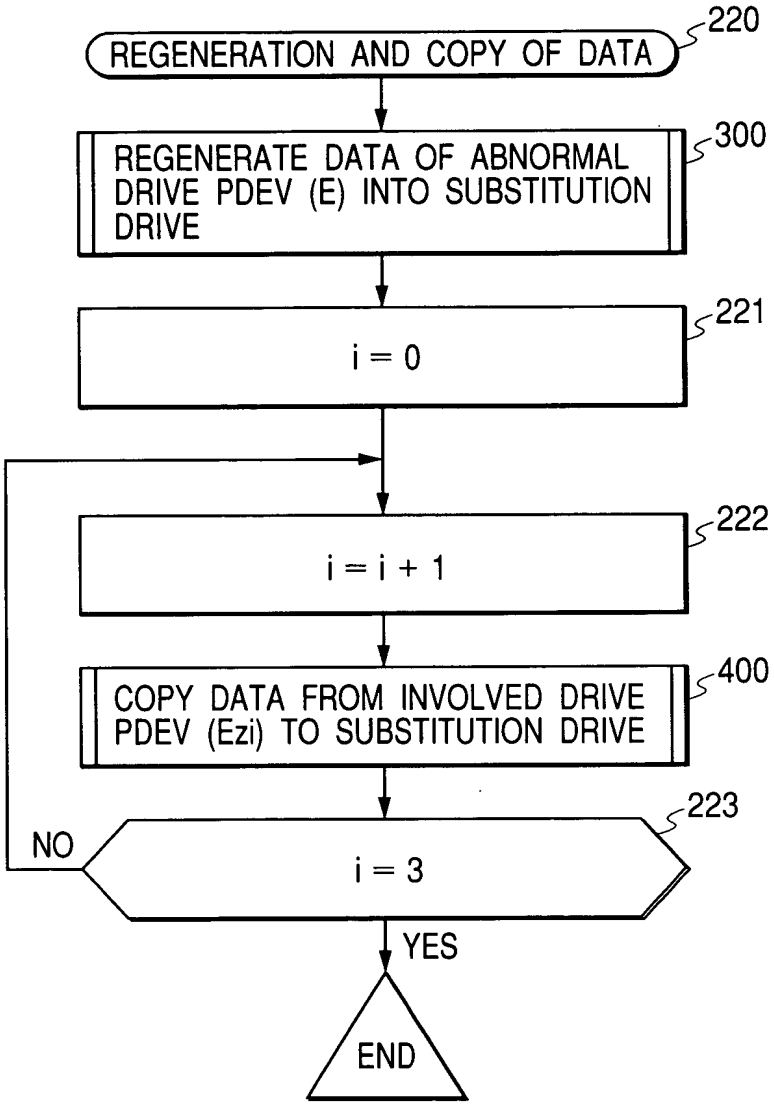

220
REGENERATION AND COPY OF DATA
300
REGENERATE DATA OF ABNORMAL DRIVE PDEV (E) INTO SUBSTITUTION DRIVE
221
i = 0
222
i = i + 1
400
COPY DATA FROM INVOLVED DRIVE PDEV (Ezi) TO SUBSTITUTION DRIVE
223
NO
i = 3
YES
END

FIG. 15

DATA REGENERATION MANAGEMENT TABLE 83

831 AREA NUMBER	832 LOGICAL BLOCK ADDRESS		833 REGENERATION FLAG	
	FROM	TO		
0	0x00000000	0x0000FFFF	1	830-0
1	0x00010000	0x0001FFFF	1	830-1
2	0x00020000	0x0002FFFF	1	830-2
3	0x00030000	0x0003FFFF	1	⋮
4	0x00040000	0x0004FFFF	0	
5	0x00050000	0x0005FFFF	0	
6	0x00060000	0x0006FFFF	0	
7	0x00070000	0x0007FFFF	0	
8	0x00080000	0x0008FFFF	0	
9	0x00090000	0x0009FFFF	1	
10	0x000A0000	0x000AFFFF	0	

FIG. 16

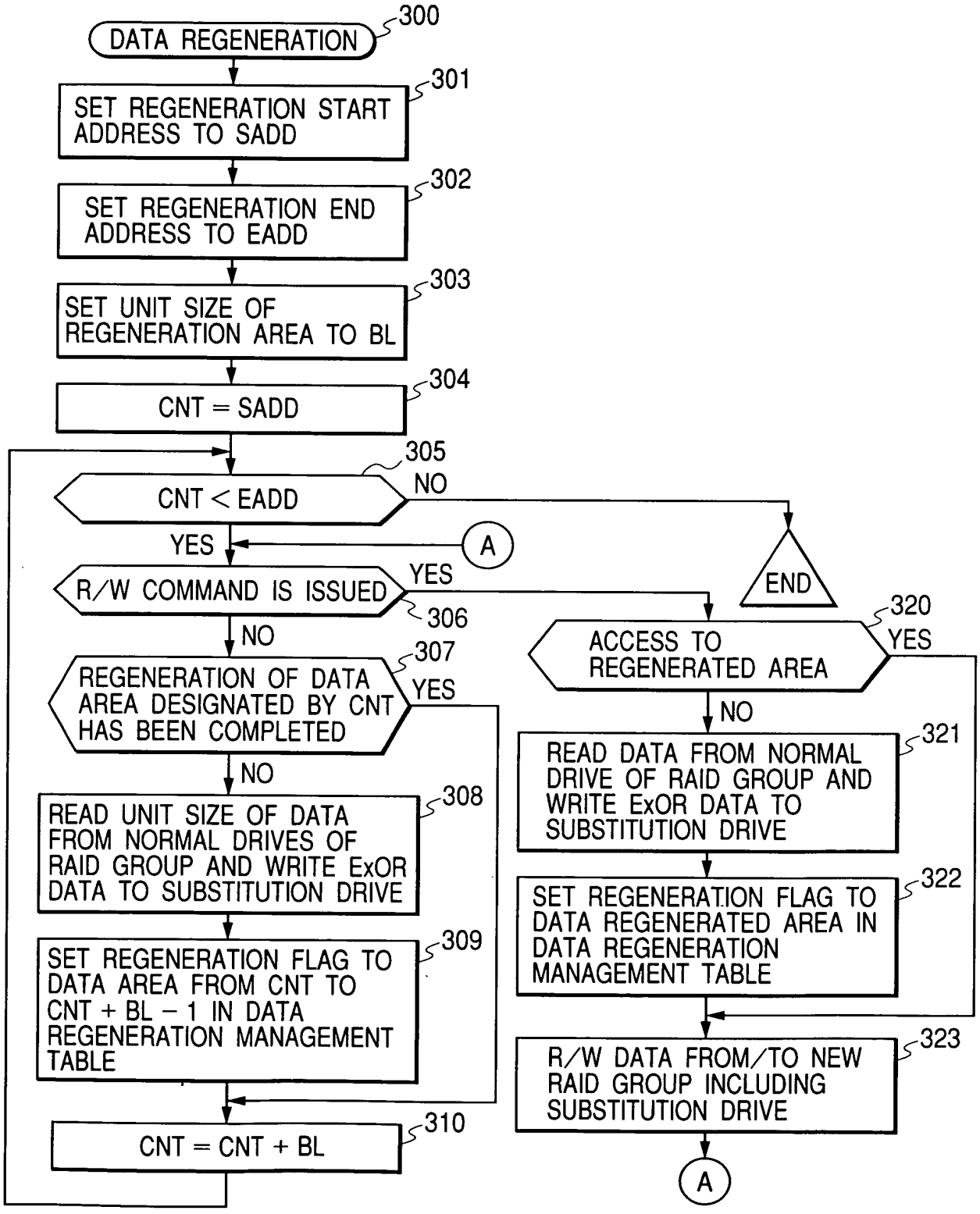

DATA REGENERATION
300
SET REGENERATION START ADDRESS TO SADD
301
SET REGENERATION END ADDRESS TO EADD
302
SET UNIT SIZE OF REGENERATION AREA TO BL
303
CNT = SADD
304
CNT < EADD
305
NO
YES
A
R/W COMMAND IS ISSUED
YES
306
NO
REGENERATION OF DATA AREA DESIGNATED BY CNT HAS BEEN COMPLETED
307
YES
NO
READ UNIT SIZE OF DATA FROM NORMAL DRIVES OF RAID GROUP AND WRITE ExOR DATA TO SUBSTITUTION DRIVE
308
SET REGENERATION FLAG TO DATA AREA FROM CNT TO CNT + BL − 1 IN DATA REGENERATION MANAGEMENT TABLE
309
CNT = CNT + BL
310
END
ACCESS TO REGENERATED AREA
320
YES
NO
READ DATA FROM NORMAL DRIVE OF RAID GROUP AND WRITE ExOR DATA TO SUBSTITUTION DRIVE
321
SET REGENERATION FLAG TO DATA REGENERATED AREA IN DATA REGENERATION MANAGEMENT TABLE
322
R/W DATA FROM/TO NEW RAID GROUP INCLUDING SUBSTITUTION DRIVE
323
A

FIG. 17

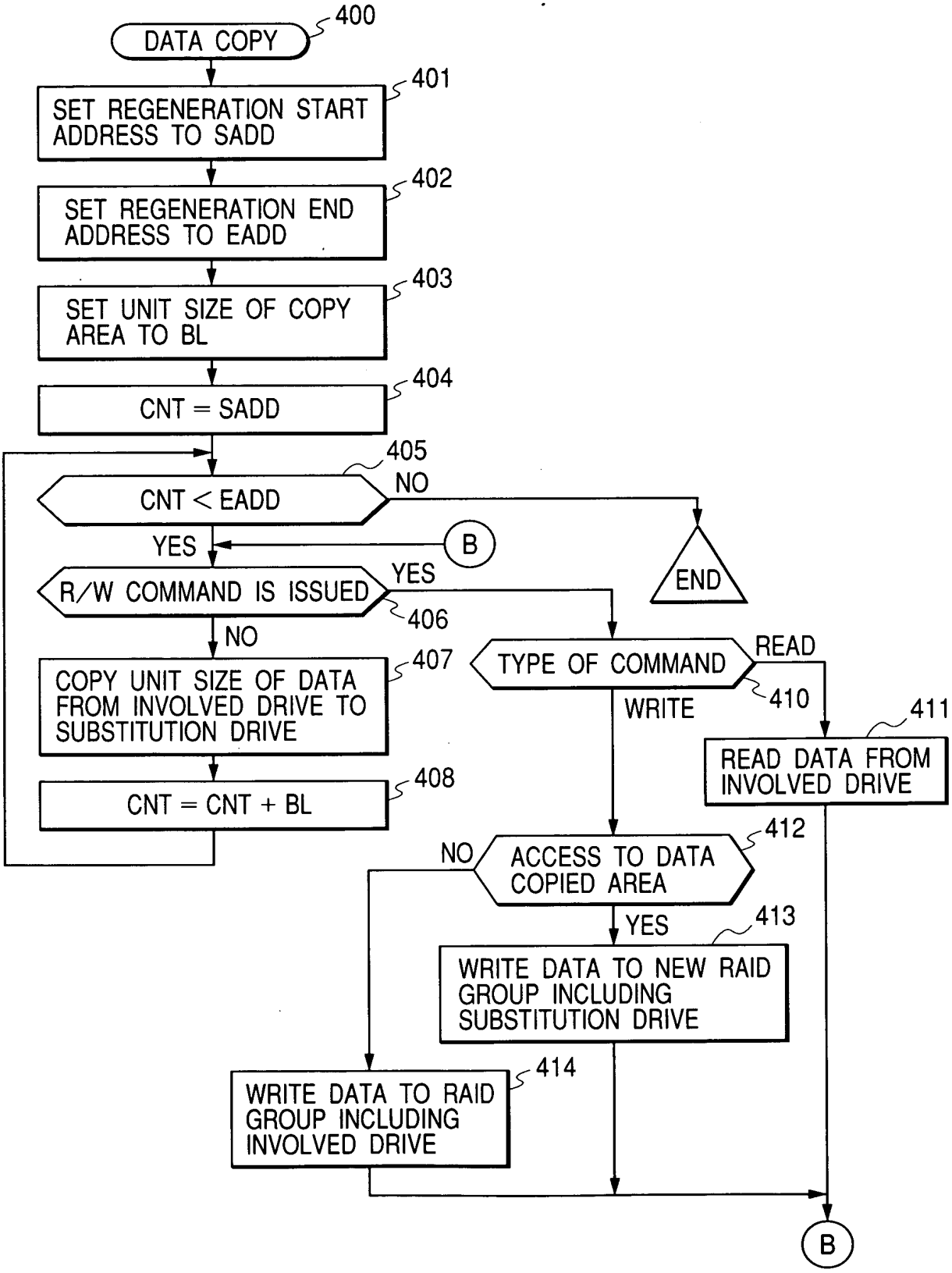
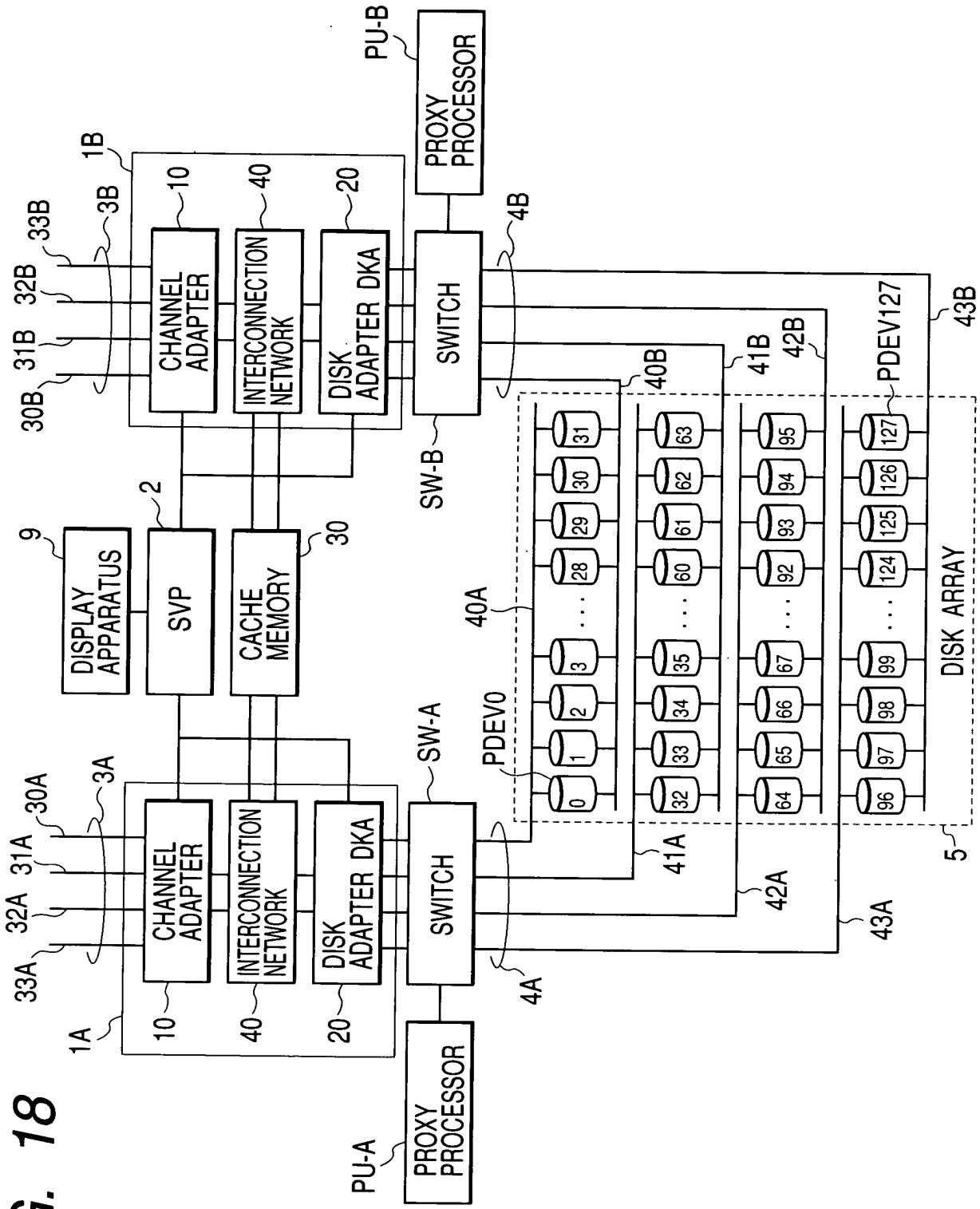

DATA COPY
400
SET REGENERATION START ADDRESS TO SADD
401
SET REGENERATION END ADDRESS TO EADD
402
SET UNIT SIZE OF COPY AREA TO BL
403
CNT = SADD
404
CNT < EADD
405
NO
YES
B
END
R/W COMMAND IS ISSUED
YES
406
NO
COPY UNIT SIZE OF DATA FROM INVOLVED DRIVE TO SUBSTITUTION DRIVE
407
CNT = CNT + BL
408
TYPE OF COMMAND
READ
410
WRITE
411
READ DATA FROM INVOLVED DRIVE
412
NO
ACCESS TO DATA COPIED AREA
YES
413
WRITE DATA TO NEW RAID GROUP INCLUDING SUBSTITUTION DRIVE
414
WRITE DATA TO RAID GROUP INCLUDING INVOLVED DRIVE
B

FIG. 18


PU-B
PROXY PROCESSOR
1B
3B
33B
32B
31B
30B
CHANNEL ADAPTER
10
INTERCONNECTION NETWORK
40
DISK ADAPTER DKA
20
SWITCH
4B
SW-B
2
9
DISPLAY APPARATUS
SVP
CACHE MEMORY
30
40A
40B
41B
42B
PDEV0
PDEV127
43B
DISK ARRAY
5
SW-A
3A
30A
31A
32A
33A
1A
41A
42A
43A
4A
PU-A
PROXY PROCESSOR